LIME FINISHING RECIPES FOR RESTORATION OF BUILDINGS AND STRUCTURES

V. I. LOGANINA[1], O. A. DAVYDOV[2] & O. V. GRINTSOVA[3]

[1,2]Professor, Department of Technical Sciences, Candidate of Science, Penza, ul. G. Titova, Russia

[3]Associate Professor, Department of Candidate of Philology, (Penza State University of Architecture and Construction), Penza, ul. G. Titova, Russia

ABSTRACT

Some information about the recipes and technology of lime finishing compositions for restoration of historic buildings is given. It is shown that the resistance of lime finishing coatings can be increased by introduction of colloidal silica sol solutions. The regularities of the silica sol particles radius changes, depending on the age are described. The regularities of structuring lime finishing compositions with sol are defined.

KEYWORDS: Silica Sol, Lime Compositions, Structuring, Restoration

INTRODUCTION

Safe keeping of the architectural heritage of the past, restoration of monuments and rehabilitation of buildings in historic areas require special materials not only to restore the appearance of the building, but also make it suitable for operation. Lime compositions have been used as traditional materials for painting facades. However, the lifetime of coatings based on lime paint is about 3 years, but often they are destroyed much earlier in about a year.

To increase the resistance of lime active mineral additives, containing amorphous silica (flask, tripoli, diatomite) are introduced. Their active interaction with lime is determined, among other factors by the fineness of their grinding, resulting in additional energy consumption for grinding. In recent years application of nanotechnology and nanomaterials has been considerably increased in the industry. A promising way of getting silica-containing additives is ion exchange chromatography, which is based on the reversible exchange of ions between the analyzed solution and ions in composition of the solid carrier (ion exchanger). An ion exchange column filled with resin cationite KU- 2 was used for getting silica sol. In this paper, a solution of sodium water glass Na_2SiO_3 with 1.46 g/cm^3 density according to GOST 13078-81 was used, it was diluted with water and passed through a cation exchange column. Table 1 shows the values of the sol particles radius, depending on age.

Table 1: Change in the Size of the Silica Sol Particles Depending on the Age

Sol Age 24 Hours	Radius of Sol Particles, nm
1 hour	17,1
1 day	17,2
3 days	17,6
5 days	17,9
7 days	131,2
12 days	134,3
15 days	143,0
19 days	143,0

The results of calculation show that from the age of 7 days consolidation of sol particles begins. So, at the age of 1-5 days the radius of sol particles is 17, 1-17, 9 nm, and at the age of 7-19 days - 131.2 - 143nm [1]. The results show that

electrokinetic potential of the dispersed system defined by electrophoretic method is 0.053B. For the characteristics of the obtained sol ion diffusion layer thickness was calculated. The results show that the diffusion layer λ thickness is λ = 7, 96 nm. Ultramikrogeterogennye systems (sols) are peculiar because their particles are involved in thermal motion, according to molecular kinetic laws. Root mean square particles shift was calculated for the time interval τ in accordance with the law of Einstein - Smoluchowski. It is found that sols with a particle radius r = 17,1 nm root mean square value of the Δx shift for 10c is 1.58 microns, and sols with a particle radius 143nm -0.55 microns. The results also confirm higher activity of the sol particles at the age of 5 days. The effective stabilizer of silica sol are gelatin and PVA which help to prevent coagulation of the silica sol.

To estimate the amount of the sol, which was used for interaction with lime, they have determined the pH change of the system "lime – sol". For this purpose, in a flask containing a specific amount of sol with estimated concentration and pH they have put a sample of lime Ca (OH) $_2$ and pH of the system was measured by a pH meter. The quantity of sol m was determined in accordance with stoichiometric balance equation for interaction of lime with the sol. Figure 1 shows the kinetics of the pH of the system " lime - sol " depending on the content of lime.
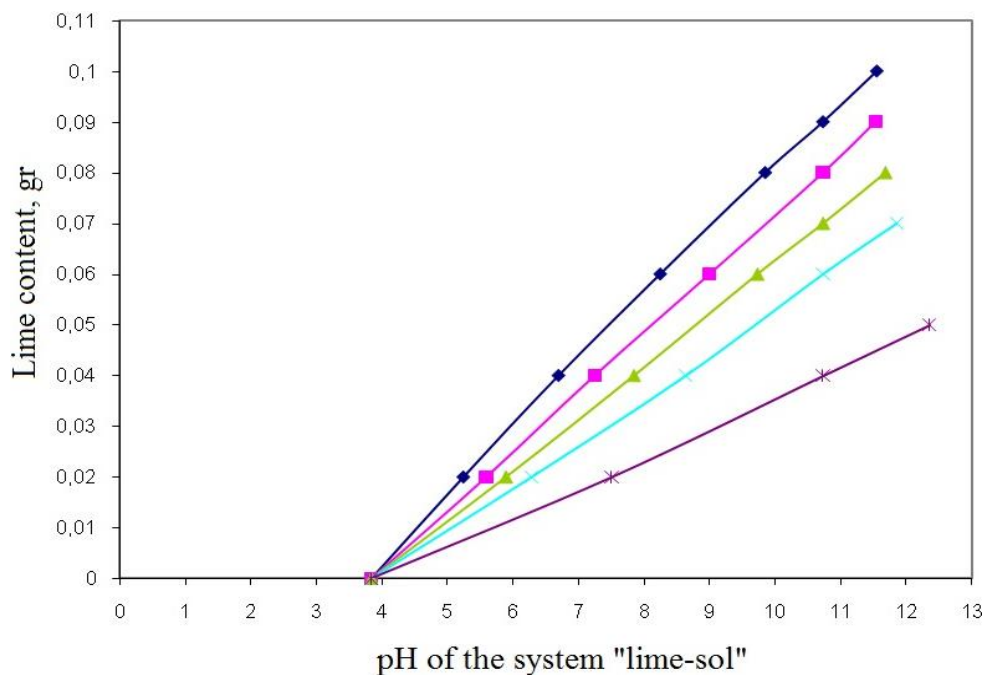

Figure 1: Kinetics of pH Change in the System "Lime - Sol" Depending on the Lime Content: 1 - 1 Day, 2 - 3 Days 3 - 5 Days, 4 - 7 Days, 5 – 10 Days

The interaction of weak polybases acids with strong bases, which include lime Ca (OH)$_2$, the position of the first equivalence point can be determined by the formula:

$$pH_1 = \frac{pK_1 + pK_2}{2},$$

(1)

where K_1 - N$_2$SiO$_3$ dissociation constant for the first stage; K_2 - the dissociation constant for the second step. Given that $K_1 = 2.2 \times 10^{-10}$ and $K_2 = 1.6 \times 10^{-12}$ first equivalence point is $pH_1 = 10.73$. They have calculated the amount of sol for reaction with lime, at pH corresponding to the first equivalence point, i.e. $pH_1 = 10.73$. It is taken into account that in the first stage, ie at the equivalence point, the amount of reacted sol is ½ of the total amount of reacted sol. Table 2 shows the numerical values of the sol activity, depending on its age.

Table 2: Changes of Sol Activity, Depending on the Age

Sol Age, Days	Sol Activity, %
22	1
19	3
16	5
14	7
10	10

In assessing the interaction of lime with silica sol they have determined the amount of heat released during lime wetting with sol SiO_2. The quantity of heat was calculated by the formula:

$$Q = \frac{c\Delta t m_n}{m} \qquad (2)$$

where c - specific heat kJ / (kg° C);

Δ t - temperature change, °;

m_n - sample weight in kilograms;

m - lime mass kg

The calculations have shown that the amount of heat Q, released during lime wetting with SiO_2 sol was 15.0 kJ / kg, and when wetting lime with water - 10.6 kJ / kg. It is estimated that the contact angle of the limestone substance wetting with sol is 58 °, and with water 53 °, the surface tension of the sol does not differ from the value of the surface tension of water and is 69.8 erg / cm ². 2% SiO_2 sol was introduced together with the mixing water into the mortar mixture, the ratio of lime: sol was 1:0.25, 1:0.5, 1:1. It was found that the introduction of sol into lime mixture accelerates plastic strength setting. Thus, in 48 hours after mixing the elastic strength of the composition with sol SiO_2 (the ratio of L: sol = 1:1) was 0.09 MPa and in the control composition - 0.01 MPa. Increase of the sol age up to 11 days reduces the activity of interaction with lime. Thus, in 48 hours the strength of the plastic additive with the sol (the ratio of L: sol = 1:1) was 0.03 MPa, while in the composition with the addition of the sol (age 1 hour) at a ratio of L: sol = 1:1 – it was 0.09 MPa. Introduction of additive sol (sol 1h age) increases compressive strength of the mortars. Compressive strength of a mixture with ratio I: II = 1:3, V / D = 2 (ground sand specific surface Ssp = 5065 cm^2 / g) with the addition of the sol at a ratio of I: sol = 1:0.5 at the age of 7 days was R_c = 0.68 MPa and at the age of 56 days of age R_c = 0.95 MPa, whereas that of the control composition, respectively R_c = 0.25 MPa and 0.61 MPa R_c.

Increase age of the sol age up to 11 days, as was mentioned above, reduces the efficiency of the additive and causes minimal increase in the compressive strength after 28 days of air-dry hardening which at ratio L: sol = 1:1 39 % [2]. The strength increase of the compositions when lime silica sol is added was due to the physico - chemical interaction of the sol with lime. We determined the amount of free lime Ca (OH) $_2$ in the hardened lime composition. For this purpose the samples of mortar composition of 1:4 (control additive and sol at a ratio of lime: sol = 1:1) were formed. After curing in air- dry conditions for 28 days the tested were samples were grounded into powder and placed into a desiccator to avoid carbonation, and then used to determine the lime content by method of GOST 5382-91. It is found that the content of free lime in the control compositions is 49.8 % by weight of lime used for the paste, with the addition of the sol - 39.6 %, which is the evidence of chemical interaction of lime with sol. The recipe and technology of lime finishing compound has been developed. The finishing coating is characterized by a high bond strengths and a wide range of colors Table 3.

Table 3: Technological and Operational Properties of Finishing Compositions

Indicator	The Exponent Finishing Composition	
	Developed	Prototype
Adhesion strength R_{sts} MPa	0,9…1,6	0,5…0,7
Cohesive strength R_c, MPa	1,7…1,9	0,8…1,1
Viability hour - When stored in open containers - When stored in closed containers		8…10 40…48
Drying time to degree "5" at (20 ± 2) ° C, min, max	60	60
Water-holding capacity, %	97	no less than 98
Recommended thickness of a single layer, mm	Up to 10	3-30
Fuel finishing composition for application 1 layer 0.3 mm thick, kg/m^2		0,2…0,4
Consumption of finish when applied in one layer with a thickness of 10 mm, kg/m^2		1,0…1,1
Workability	good	good
Cracks due to shrinkage	no	no
Nk resistance to static exposure of water at (20 ± 2) ° C, h, not less	72	24
Water vapor resistance $\cdot$ 10-5 m^2 $\cdot$ h $\cdot$ Pa / mg		
Nature of the surface finishing layer	Texture (smooth)	smooth
water resistance	0,5	0,4

REFERENCES

1. Loganina V.I Davydov O.A.Izvestkovye finishing compositions based on sol-gel technology//Building Materials -2009, No 3 - P.50 -52

2. Loganina V.I Davydov O.A. Tehnologicheskie properties lime finishing compositions// News KSUAE. - 2009, No 9 - S. 284.